“Sustainable Agriculture: Instruction, Application, and Community Outreach Utilizing Recirculating Aquaponics Systems”

Final Project Report

Youth Educator Sustainable Agriculture Grant
YENC-13-067
March, 2013 – March, 2015

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Acknowledgements

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We also acknowledge the financial and administrative support of CHCA, especially Dr. Dean Nicholas (High School Principal), Dr. Lu Taylor (High School Science Department Head) and Heather Wilkowski (Director of High School Operations). Mark Bishop and Tyler Eifert of CHCA's Facilities Management team provided invaluable assistance with construction projects in our laboratory. The students of Environmental Science I and II of academic years 2013-2014, and 2014-2015 are responsible for the construction and operation of various aquaponics systems presented in this report.

Finally, we would like to acknowledge CHCA alumnus Nick Elder (Class of 2014) for his design of the CHCA Aquaponics logo. Nick was a student in the Sustainable and Urban Agriculture course in 2013-14. He designed the logo (shown on the title sheet of this report, and below in larger format) to (1) include both of the "fish and produce" components of a recirculating aquaponics system, and (2) the globe in the background to acknowledge the potential global impact of sustainable agriculture in general, and aquaponics, specifically, in helping to meet food needs. Nick also incorporated CHCA's school colors (deep purple (fish), and forest green (plants)) into the logo to subtly include CHCA as a part of the sustainable agriculture education process.

Project Abstract

This project focused on recirculating aquaponics systems as a closed-loop form of sustainable agriculture. Aquaponic gardening as a sustainable agriculture method is not a new method, having been refined and implemented on a large scale at the University of the Virgin Islands some 30 years ago. It is, however, a relatively new teaching tool in secondary science classrooms. Over the past four years, faculty at Cincinnati Hills Christian Academy (CHCA) have utilized aquaponic systems to teach and reinforce science concepts that are intimately related to sustainable agriculture, all within a traditional high school course sequence: botany, seed germination, plant growth, pollination, biogeochemistry and plant nutrients (Biology), biogeochemistry of natural systems, and chemistry of aquatic systems (Chemistry), biogeochemical cycling, urban agriculture, and sustainable agriculture (Environmental Science). Over the course of a four-year curriculum, students learn the basics of aquaponics as a method of sustainable agriculture, and then have the opportunity to apply their knowledge through the design, construction, operation, and monitoring of a fully-functioning aquaponics system. The upper level students also explore the "end products" of sustainable agriculture through exposure to "food deserts", and the connection between access to fresh produce and protein and effects of lack of good nutrition on the overall health and fitness of those who lack access. Additionally, implementation of a variety of aquaponic system types has created opportunities for students and faculty to engage in independent research, as well as collaborative research with a local university. Finally, interaction with the community outside of CHCA has allowed students and faculty alike to experience a transfer of knowledge and skills gained in a classroom setting to the "real world".

Project Description

The funds awarded to CHCA through Youth Educator Grant YENC-13-067 have been used to construct and facilitate initial operation of a large vertical tower aquaponics system. As constructed, the system consists of twelve (12) ZipGrow® towers (each tower is five feet in length) from Bright Agrotech, LLC (www.brightagrotech.com), a 100-gallon stock tank for the fish, an external biofilter, and all of the associated plumbing to connect the various components, and woodwork for framing and to provide structural support.

The system design was completed with technical assistance and guidance from Dr. Nate Storey of Bright Agrotech, LLC; system construction, including plumbing, was completed by students in the Environmental Science I & II (Sustainable & Urban Agriculture) course sequence working under faculty supervision. The system, as shown below in Figure 1, consists of ZipGrow® towers mounted in a wooden framework at 8-inch, on-center spacing to replicate standard spacing between rows in other aquaponic systems, as well as traditional soil garden systems. The tops of the towers are approximately 7' 4" above the laboratory floor; this allowed placement of a single gutter-type drain system to catch water flowing downward through the towers, and return the water to the fish tank. This height also allows the fish tank to fit vertically beneath the gutter to allow all "return" water movement to be gravity-driven, eliminating the need for an intermediate sump and water pump. Fish tank water, containing dissolved fish waste, fish waste solids, and uneaten fish food, is drained from the bottom of the fish tank to the biofilter by hydrostatic pressure from the water in the fish tank (Figure 2). Water flows into the top of the biofilter, where woven filter media removes the majority of suspended solids, and allows low turbidity water to flow downward into the biologically-active portion of the filter where nitrifying bacteria convert the dissolved fish waste (principally ammonia, NH_3) into nitrite (NO_2^-), and the nitrite into nitrate (NO_3^-). The water reaching the bottom of the biofilter, now enriched with nitrate, is pumped via irrigation tubing to the top of each tower, where it trickles downward over and through the root system of the plants in the tower. The nitrate is taken up by the plants as a source of nutrition, and water with lower nitrate concentrations is returned to the fish tank to complete the flow cycle. As constructed, the entire system (including fish tank and external biofilter) occupies only 20 square feet of laboratory floor space, but provides more than 60 square feet of growing space.

Figure 1. Rough construction of vertical tower aquaponics system showing towers, wooden supporting framework, and fish tank. The biofilter is not shown in this photo.

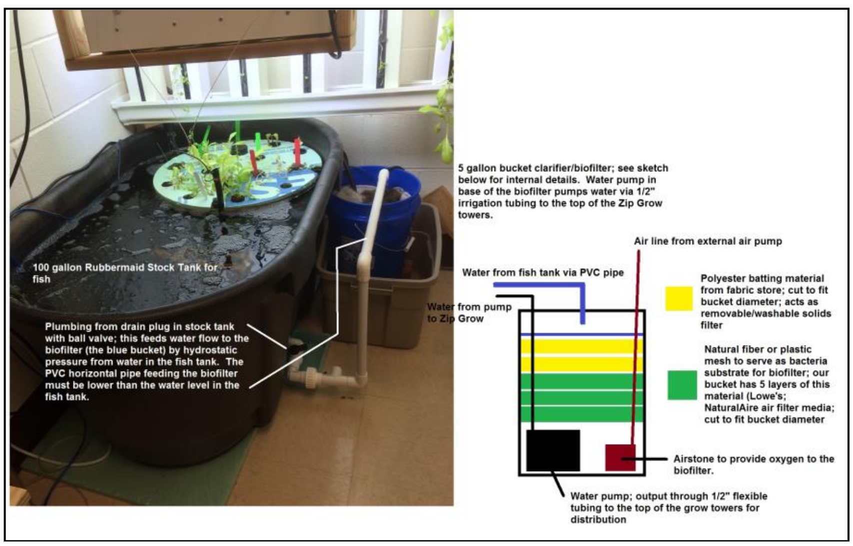

Figure 2. Detail showing plumbing configuration, and schematic of biofilter design for the vertical tower system.

Because the system has been constructed in an interior laboratory of the school, it was necessary to add grow lighting for the system. The grow lighting consists of two Sunblaze Sunsystem

48 T-5 High Intensity Discharge light units mounted vertically to maximize light coverage for the towers. One light is mounted in a rolling frame which allows the light unit to be moved to allow access to the towers for planting, measuring, harvesting, and periodic maintenance and cleaning. Because of the fish tank, the second lighting unit could not be placed on a rolling frame. Instead, the students brainstormed, and designed a frame for the fixture, which is mounted to a flat-screen television wall mounting unit; this allows the fixture to be moved into, and out of position in front of the towers for access (Figure 3).

Figure 3. Mobile light tower with rolling frame (left) and wall-mount light tower (right) for vertical tower system.

Students select crops, and then seeds from the CHCA Organic & Heirloom Seed library for planting. Over the course of this project a variety of media were utilized for seed planting and germinating, but the two primary media were Grodan A-OK 1.5” rockwool starter plugs, and GrowTech Flexicube 1” starter plugs. Plants selected for growing in the vertical tower system have included Genovese basil (Figure 4), Thai basil, mesculun lettuce blend, Russian kale, cilantro, marjoram, sage, Swiss chard. All have grown successfully, and thrive in the tower system. As plants reach maturity, they are harvested by the students (Figures 5 & 6). Students record relevant data on logging sheets with each system, including date of seed planting, date of harvest into the tower system, date of harvest, age of the plant at harvest (from seeding), and biomass of the harvest. At

Figure 4. Genovese basil seedlings in GrowTech Flexi-Cube starter pots; approximately 10 days after planting.

Figure 5. Student harvesting Genovese basil by cuttings.

present, students are developing planting schedules, based on observed germination and growth-to-maturity times to allow cyclical planting, growing, and harvesting of the towers.

Figure 6. Students with harvest of mesculun lettuce blend, Genovese basil, and sage from two towers in the svstem.

Students in the Sustainable and Urban Agriculture course are responsible for ongoing operation and maintenance of the vertical tower system, as well as six additional aquaponic systems of various configurations in the CHCA Aquaponics Laboratory. Students test water chemistry (Figure 7), monitor fish tanks for water level and cleaning needs (including identification and removal of dead fish), keep automatic fish feeders filled, provide periodic cleaning of solids filter media in the biofilters, monitor plant growth, and check regularly for insects and other pests in and around the grow beds. As a part of water quality testing, students and faculty together identified the key parameters to provide assessment of the health of the water, and which parameters need to be monitored on a (a) daily, (b) weekly, and (c) monthly basis. A water quality monitoring data sheet was developed, and is used by students to ensure completeness in the data collection.

Figure 7. Students conducting water quality testing using colorimetric test kits and a water quality colorimeter.

In addition to all of the tasks associated with the plant portion of the system, students also are responsible for care, and data collection activities associated with the fish portion of the system. The fish in the system are a mix of Nile and blue tilapia (*Oreochromis niloticus*, and *Oreochromis aureus*, respectively) obtained as fingerlings (1 – 5 grams in size) from the Shekinah Ranch Aquaculture Center in Dayton, OH. Fish growth is monitored by periodic measurement of a random selection of fish. As the fish grow to harvest size (500-600 grams), students will be taught proper technique for sacrificing the fish, as well as proper techniques for filleting the fish for use as a food item (Figures 8 & 9). Fish harvesting and

Figure 8. Student beginning to fillet harvested tilapia.

Figure 9. Student filleting harvested tilapia.

euthanasia is completed under faculty supervision, and the guidance/direction of a Livestock Care Plan found to be “acceptable”, and in compliance with euthanasia guidelines by the American Veterinary Medical Association. Copies of the Livestock Care Plan are labeled and posted in the aquaponics laboratory.

The tower system in its present configuration has been fully operational for six months, at the time of this writing. It has become the “showpiece” system in the laboratory, and is a popular tour stop for visitors to CHCA. Maturing Nile and blue tilapia populate the fish tank. Multiple, regular harvests of basil and lettuce, as well as intermittent harvests of sage, marjoram, cilantro, chard and kale have been made. Presently (March, 2015), all twelve towers are populated with a variety of plant types in different stages of growth. As plants mature later this spring, we will be allowing some of the plants to “bolt”, and produce flowers and seeds, which the students will collect, process, and store as a part of the sustainable agriculture curriculum. Plans for this spring also include growing strawberries in 1-2 towers, and a small project to test how well several varieties of hops will grow in the system.

Curriculum Development / Specific Practices Learned

Aquaponics initially became a part of the CHCA culture in 2011, when students in the Environmental Science class taught by Dr. Savage constructed a five column, vertical recirculating system using a 65-gallon aquarium, and recycled two-liter soda bottles with expanded shale media as the growing columns. This initial system was constructed as a component of a semester-long unit on agriculture and food systems, and represented an early attempt to build and operate a small-scale, sustainable crop-producing system. Though crude and somewhat rough in appearance, this system has operated continuously since its completion; the system has produced harvests which included bell peppers, hot peppers, leaf greens, kale, sweet and purple basil, and lemon balm.

Since that initial system, we and our students have constructed and operated a number of other small-systems, including rafts of basil, and leaf greens floating directly in an aquarium, and hybrid systems with media-filled and deep-water culture (DWC), or raft, beds. Systems constructed by students during the 2013-14, and 2014-15 school years include the vertical tower system funded by this NCR-SARE Youth Educator Grant, two “Barrelponics” systems (funded by a grant from the Aquaponics Association and matching funds from CHCA), and three media-filled grow bed systems. The fish component of these systems has included channel catfish, hybrid bluegill, and yellow perch, in addition to the tilapia presently being used. Although produce production in these systems has varied widely, the fish have thrived and grown to harvest size, and each system has afforded us and the students the opportunity to gain invaluable experience in the day-to-day operation of different types of aquaponics systems.

Aquaponics in the Curriculum: Since construction of the initial system, we have worked to create units or modules that utilize aquaponics to teach both basic and advanced topics in courses offered as a part of a four-year science curriculum at CHCA. Development of additional modules continues to be a work in progress; specific topics for development are impacted by year-to-year changes in course teaching responsibilities. Basic modules by grade level / course are described below.

Students at CHCA are introduced to aquaponics in freshman (9th grade) biology classes, where aquaponics is used as the basis for such learning modules as aquatic ecosystems, basic microbiology, and chemistry of natural waters. In sophomore (10th grade) chemistry, aquaponics is again utilized as the basis for modules including pH, oxidation-reduction reactions, and multi-parameter water quality testing using a variety of test-strip, wet chemistry, and probe methods for monitoring. Modules for design and construction of air lift pump systems for moving water within an aquaponics system have been outlined for use in the 11th and 12th grade physics course sequence as a part of a fluid dynamics unit; to date, however, the physics instructors have shown little interest in aquaponics, or the inclusion of this module into the physics curriculum. Beginning in 2015-16, this air lift pump module will be incorporated into the Sustainable and Urban Agriculture course curriculum.

Juniors and seniors are eligible to take the Environmental Science I & II elective course sequence. This sequence is our Sustainable and Urban Agriculture course; it provides an introduction to traditional agriculture and modern industrial agriculture, but focuses on sustainable and urban agriculture using aquaponics as the primary teaching tool. This class builds upon the experiences students have had with aquaponics in other courses, but spends significant time in the principles of aquaponics (including modules on plant and fish biology, and microbiology), the basics of design for a variety of system types, hands-on construction of one or more type of system, and operation and maintenance of multiple systems which are in the laboratory. A detailed syllabus for this course is in Appendix A of this report. In general, the first academic quarter is spent learning the role of sustainable agriculture in a global context, and the "detailed basics" of aquaponics. An emphasis is placed on an understanding of aquaponics as a "designed and constructed polyculture ecosystem", rather than simply as the melding of the sustainable agriculture methods of aquaculture (fish farming) and hydroponics (plants grown without being rooted in soil). This approach keeps the emphasis on the need to maintain system conditions that benefit all of the living components, as well as the interdependent and symbiotic relationships between the living components. In the second quarter, students use their previously-acquired math and science skills, together with their newly-gained knowledge of aquaponics system components and system types to design, and then construct a new aquaponics system. During this phase, students gain practical, hands-on experience in learning to safely operate power tools for simple carpentry tasks, and skills in fabricating plumbing systems with PVC and flexible irrigation-type tubing and fittings. Leak-testing provides an opportunity for troubleshooting and problem solving. The addition of fish, plants, and nitrifying bacteria mark the operational launch of the new system, and a transition to the operation and maintenance mode, with all of the previously described tasks related to care of the fish, plants and bacteria.

Beginning in the second quarter, and continuing through the third quarter, students explore traditional and industrial farming, food processing and production, wholesale distribution, and retail distribution of food using a curriculum entitled "*Teaching the Food System*", produced by the Center for a Livable Future at Johns Hopkins University. Aquaponic system operation and maintenance tasks continue as on-going activities throughout the third quarter. In the fourth quarter, students focus on land use and land management, with an emphasis on agricultural land use applications.

Specific Practices Learned: In the initial grant proposal, we identified 11 specific practices that our student would exposed, with an expectation of at least a rudimentary demonstration of mastery. These practices are identified in Table 1 below; the second column of the table identifies where in the Sustainable & Urban Agriculture course structure a specific practice is introduced and/or explore in depth.

Table 1. Summary of Specific Practices Learned, and their placement in the Sustainable & Urban Agriculture course curriculum.

Specific Practice Learned	Where Introduced / Explored
Global Change: Includes global population growth and feeding a growing population	Quarter 1 – Introduction to Aquaponics Quarters 2 & 3 – *Teaching the Food System*
Methods of Agriculture: Traditional vs. Industrial vs. Sustainable	Quarters 2 & 3 – *Teaching the Food System*
Heirloom/Open-Pollinated Seeds vs. Genetically-Modified Organism Seeds: Benefits & disadvantages	Quarter 3 – *Teaching the Food System*
Introduction to Aquaculture and Hydroponics: Examples of sustainable agriculture systems	Quarter 1 – Introduction to Aquaponics
Introduction to Aquaponics: Combining the best features of aquaculture and hydroponics	Quarter 1 – Introduction to Aquaponics
Aquaponics Basics & System Design: Includes system construction by students	Quarter 2 – Design and Construction of Aquaponic System
Nitrogen Cycling & the Role of Nitrifying Bacteria: Includes microscopy and bacteria identification	Quarter 1 – Introduction to Aquaponics Quarters 2 & 3 – Water Quality Monitoring
Seed Planting, Germination, and Transplanting: Students select crops, and grow plants from seed; they are responsible for all steps from planting through transplanting into the aquaponics system	Quarters 2, 3, &4 – System Operation & Maintenance
Aquaponics System Operation and Maintenance: Includes student monitoring of key water quality parameters, maintaining automatic feeding of fish, and water levels throughout the system	Quarters 2, 3, & 4 – System Operation & Maintenance

Harvesting of Fruiting Plants, Herbs, and Leafy Greens	Quarters 2, 3, & 4 – System Operation & Maintenance
Seed Recovery, Processing, and Saving: Emphasis on seed recovery to ensure seed stock for sustainability and subsequent planting.	Quarters 3 & 4 – System Operation & Maintenance

Aquaponics and Research: In addition to the core and elective course offerings involving aquaponics, a Research and Leadership program at CHCA provides students with the opportunity to pursue independent research during their 11^{th} and 12^{th} grade years. At the time of this writing, there are five students conducting research in aquaponics under our direction, and with additional guidance from aquaponics professionals outside of the school community, and research faculty & doctoral students from the University of Cincinnati. Two students are currently completing their two-year projects, and will be presenting the results of their work as a capstone presentation and document in late April or early May of 2015. The remaining students will be seniors (2) and one junior next academic year, and will be continuing the collaborative projects with the University of Cincinnati personnel. In addition to the internal capstone presentation and document, each student has a requirement to share the results of their work with the aquaponics community at large by presentation at professional meetings, publication, or both.

Future Direction: As the aquaponics program at CHCA continues to grow and evolve, we continue with the task of updating existing curriculum modules, and developing new modules to be consistent with guidelines and objectives identified in the Next Generation Science Standards (NGSS). The State of Ohio is a lead-state partner involved with the development and implementation of these standards, and revision and on-going development of new modules that are consistent with NGSS objectives is a priority for our program. Development work and refinement of existing modules to fit within the paradigm of STEAM (Science, Technology, Engineering, **Agriculture**, and Mathematics) is also underway. Preliminary results of these efforts were presented in February, 2015 at the Environmental Education Council of Ohio's "Winter Snow STEM Conference" in Perrysville, Ohio.

Planning is presently underway for the 2015-2016 academic year to include financial modules into the Sustainable and Urban Agriculture course, so that students will be exposed to the "money" side of aquaponics, including fixed costs of system design and construction, on-going operation and maintenance costs. Future planning beyond the 2015-2016 academic year will include an extended module on business plan preparation as a part of CHCA's Social Entrepreneurship program.

Aquaponics in the Community

As a Christ-centered institution, faculty and students at CHCA are actively engaged in service opportunities at the local, regional, national, and international levels. An individual's involvement in a given opportunity is typically a reflection of her or his personal passion. Over the past year, we have been fortunate to have been involved in two significant projects involving aquaponics in the greater Cincinnati community. During July and August of 2013, the Cincinnati Park Board's Krohn Conservatory hosted an exhibit focused on sustainable agriculture methods called "Let It Grow." The exhibit included aeroponics, hydroponics, and vertical gardening, but the centerpiece of the exhibit was a large aquaponics system with both deep water culture and dutch bucket components. We provided water-quality monitoring at a system prototype during the spring and early summer, and were invited to assist with installation of the exhibit (Figures 10 & 11), and subsequently provided regular water-quality monitoring through the duration of the exhibit, as well as a Saturday community lecture for Conservatory patrons.

Figure 10. Youth adding juvenile catfish to the Krohn Conservatory aquaponics system.

Figure 11. Installation of plants into the deep-water culture system (top), and completed installation of deep-water culture system (bottom), Krohn Conservatory

Also in July 2013, the Cincinnati Zoo and Botanical Gardens completed construction of a greenhouse to house two hybrid media bed and deep water culture bed aquaponics systems (Figure 12). We worked with the same core group of aquaponics professionals, and again provided water-quality testing support for this project during system start-up. CHCA faculty and students have continued to coordinate with Zoo staff to provide water quality testing on an on-going basis. Produce

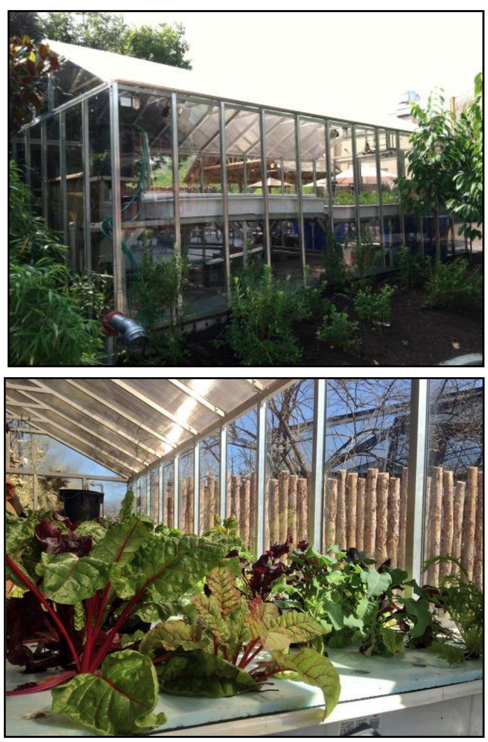

Figure 12. Aquaponics greenhouse at the Cincinnati Zoo & Botanical Gardens (top); chard and lettuce growing in the deep-water culture system.

being grown in these systems is being used by the executive chef of the Zoo's sustainable restaurant, called The Base Camp Café.

Additionally, we are in the initial stages of proposing and (hopefully) developing a plan for CHCA students and faculty to assist with an aquaponics system at a local community service agency called Gabriel's Place, in the Cincinnati community of Avondale. It is hoped that this can be in place for the 2015-16 school year.

Project Evaluation

This project, and the funding provided by NCR-SARE, has been the single largest impetus behind the growth and development of the aquaponics program at CHCA. Through this project, students and faculty have gained invaluable insight into the design, construction, and successful operation of aquaponic systems. This has opened the door for students and faculty alike to share the results of classroom instruction and research as formal presentations at a variety of professional conferences and meetings (see Appendix C for title slides of presentation). The opportunity to present has increased the level of credibility of the program, creating an opportunity for CHCA students and faculty to be active principal researchers in a long-term cooperative research program with Ph.D. students and research faculty from the Chemistry Department at the University of Cincinnati. Increased credibility has also opened the door for us to begin to be able to introduce aquaponics as a dynamic model for classroom STEM instruction to other secondary educators as instructors of a one-day workshop offered through the Greenacres Foundation (http://www.green-acres.org/) in Cincinnati, Ohio, and the University of Cincinnati.

Award of the Youth Educator Grant was instrumental in our program being awarded a $1000 microgrant from the Aquaponics Association (http://www.aquaponics-assoc.org/) and an additional $1000 matching grant from CHCA to fund design and construction of two "Barrelponics" hybrid aquaponic systems. One system is being donated to an urban elementary school for use as a part of a multi-grade science program. CHCA faculty and students will be involved in the transfer and installation of the system at the new school, and in providing mentoring and instruction to the teaching staff at the school to be able to successfully operate the system.

Through the curriculum and outreach components of the project, we have been able to refine and focus the vision for the short-term continued growth and development of the program. We have also been able to use all of the tasks completed as a part of this project to lay the groundwork for a significant growth step program: installation of a multi-bay, on-campus greenhouse to support (1) classroom instruction, (2) multi-disciplinary student and faculty research, and (3) operation of a small, commercial-type system as a micro-business enterprise under the CHCA Social Entrepreneurship Program.

As classroom instructors and research mentors, we are extremely grateful for the financial support and professional encouragement of NCR-SARE, and the NCR-SARE staff. We wholeheartedly endorse the Youth Educator Grant program as providing financial assistance to allow educators to attempt and implement non-traditional and innovative approaches to classroom instruction. We give the program our strongest endorsement, and would encourage our education colleagues to actively pursue funding opportunities through NCR-SARE.

Appendix A

Course Syllabus
Environmental Science I & II
Sustainable & Urban Agriculture

Course Title: Environmental Investigations I & II
Instructor: Mr. Gary A. Delanoy / Dr. Kevin M. Savage
Academic Year: 2014-2015

<u>Course Description</u>:
Environmental Investigations I is designed to be taken by students who have successfully completed the Introductory or VT Biology, and Chemistry courses, who have completed or are completing Introductory or VT Physics, and who have completed second-year of algebra. As such, students are expected to have previous knowledge of foundational concepts in each of these disciplines. The Environmental Investigations course sequence is designed to be an introduction to the diverse subject area of environmental science, with a focus on application of laboratory, field (outdoor), and computer-based techniques for studying the world in which we live. In particular, this course sequence will include an extended and in-depth study of ecosystems and agriculture, with emphases on traditional, industrial, and sustainable agriculture methods, aquaponics, and the food system. Students will be challenged to be critical and independent thinkers. They will be expected to analyze scientific and societal issues using scientific problem solving, and do so in light of the teachings of the Bible. Laboratory and field experiments are designed to reinforce concepts taught during the lecture portion of the course with students working in collaborative teams to develop good scientific laboratory skills and be able to make valid conclusions and effectively communicate these in both written and oral forms. Completion of the Environmental Investigations sequence by students who are juniors will provide a solid foundation for those who wish to pursue the AP Environmental Science course as seniors.

The Environmental Investigations course sequence is broken roughly into the three broad subject areas listed below. Units I and the first portion of Unit II will be covered during the first semester (Environmental Investigations I); the second portion of Unit II and Unit III will be covered during the second semester (Environmental Investigations II).

I. Aquaponics and Recirculating Aquaculture Systems
II. The Food System
III. Land Usage

<u>Course Assessment</u>:
Students will demonstrate learning and mastery through their performance on tests, quizzes, laboratory experiments, homework assignments and research projects. Quizzes, tests, and exams may include questions in a variety of formats, including matching, multiple choice, short answer, extended answer (essay), and free response (to include calculations). These assessment will include questions from lecture, laboratory, field, and computer portions of the course. Hands-on, interactive laboratory and field experiments will be conducted in parallel to the content being covered in the lectures. Break-down of students' performance evaluations will be as follows:

Tests / Quizzes	25%
Homework	15%
Laboratory Assignments / Projects	50%
Participation	10%

In addition to evaluation based on written work, students will demonstrate learning through evaluation by performance assessments where rubrics clearly list evaluation criteria and levels of performance possible. These rubrics will be distributed at the time of the assignment is announced in order to give students a "blueprint" for achieving success. The rubric is intended to make clear to students the basis their work will be evaluated. Criteria may include demonstration through written and oral communication, collaborative team work, construction of understanding, or other modes of expression.

Parent Access to NetClassroom:
Grades calculated in teacher's gradebooks appear in each student's NetClassroom account. Grades are calculated using category averages. Category averages will be determined based on the following:

Category	Graded	Calculation Type	Weight
Tests / Quizzes	Yes	Total points	25
Homework	Yes	Total points	15
Lab Assignments / Projects	Yes	Total points	50
Participation	Yes	Total points	10

Assignments:
All assignments (homework, labs, and projects) must be turned in on time. Students will lose 25% of the grade for that assignment for the first day that it is late without a valid reason, and an additional 25% for the second day. On the third day after an assignment is due, the missing assignment will be scored as a zero. ***It is imperative that students not fall behind on assignments.*** Please note that homework will be graded for correctness, not based on completion of the assignment. Although opportunities for "extra credit" will be infrequent, students must submit ALL assignments to be eligible to receive extra credit at the end of a grading period; missing assignments will preclude the student from extra credit points.

Laboratory: There are several considerations specific to the laboratory portion of the course:

- All students will be required to wear protective eyeware as directed while working on laboratory experiments. The school provides protectives goggles for the students to wear; these goggles are cleaned and disinfected regularly. A student may choose to purchase her/his own protective eyeware for laboratory use. Please see the instructor for examples of acceptable protective eyeware.
- All students will be required to wear closed-toed shoes while working in the laboratory (i.e., no sandals, flip-flops, etc.), and may also be required to wear long pants while working on a laboratory exercise. Students will be reminded in advance of upcoming laboratory days, and specific clothing requirements.

Field Activities: There are several considerations specific to the field (outdoor) portion of the course:

- All students will be required to wear protective eye-ware as directed while working on field experiments. The school provides protective goggles for the students to wear; these goggles are cleaned and disinfected regularly. A student may choose to purchase her/his own protective eye-ware for laboratory use. Please see the instructor for examples of acceptable protective eye-ware.
- All students will be required to wear closed-toed shoes and long pants while working in the field (i.e., no sandals, flip-flops,, shorts, skirts, etc.). Sweat or warm-up pants are acceptable for this purpose. Students will be reminded in advance of upcoming laboratory days, and specific clothing requirements.

Resources:

Primary Texts: ***Aquaponic Gardening***, Sylvia Bernstein, © 2011, New Society Publishers

Teaching the Food System, Johns Hopkins University, Center for Sustainable Living, © 2011 (Curriculum resources only; no text provided)

Investigations in Environmental Science: A Case-Based Approach to the Study of Environmental Systems., Daniel C. Edelson, Northwestern University in association with Herff Jones Education Division & It's About Time, 2005.
Unit 1: Land Use

Instructional Materials:	There are several ancillary materials that students will need to purchase for this course. • A 3-ring binder with looseleaf is needed for class notes
Research Resources:	Students will use the pre-screened internet sites and library resources (both CHCA's library and local libraries) to conduct research on various topics as they relate to the content being covered in class.
Guest Speakers:	Students will participate in discussion with local professionals to learn about the types of careers available to those interested in the field of environmental science.

Course Title: Environmental Investigations I & II
Instructor: Mr. Gary A. Delanoy / Dr. Kevin M. Savage
Academic Year: 2014-2015

Course Outline: *(subject to change based on discretion of the instructors)*

Time	Unit of Study
	Unit 1. Aquaponics "Aquaponics is the cultivation of fish and plants together in a constructed, recirculating ecosystem utilizing natural bacterial cycles to convert fish wastes to plant nutrients. This environmentally friendly, natural food-growing method that harnesses the best attributes of aquaculture and hydroponics without the need to discard any water or filtrate or add chemicals." *Aquaponic Gardening Community, 11/2010*
0.5 week Chapters 1 & 2	**Introduction and History of Aquaponics:** Students will be introduced to aquaculture and hydroponics as the foundational building blocks for aquaponics, and the potential role for aquaponics in the area of future food economics. Future food economics will be discussed in light of population growth, increased standard of living, increasing demand & decreasing supply, petroleum and water use in agriculture, and climate change.
0.5 week Chapters 3 & 4	**Benefits of Aquaponics and Applications:** Benefits of aquaponics in providing a sustainable source of fish and vegetables in a variety of system sizes and types will be introduced.
1 week Chapters 5 - 9	**Types of Aquaponics Systems and System Components:** Major types of recirculating aquaponics systems will be introduced, including strengths of each system type. Components that make up each system, and the purpose and function of each will be discussed in detail. *Students will assist with the design, planning, and construction to complete two partial aquaponics systems, as well as completely construct a "barrelponics" system from a set of plans. The construction, and operation and maintenance of these systems will continue for the duration of the academic year.* **Activities / Lab Exercises:** *(1) Aquaponics Systems Introduction , (2) NFT System Completion , (3) ZipGrow Tower System Construction , (4) Barrelponics System Construction, (5) Barrelponics Construction Video Documentation Project*
0.5 week Other Resources	**Controlled Environmental Agriculture and Greenhouse Efficiency:** Students will be introduced to the principles and strengths of controlled environment agriculture, and the basics of greenhouse operation. Students will identify and summarize the necessary major components to an operating greenhouse system **Activities / Lab Exercises:** *(1) Greenhouse Systems and Components*
1 week Chapter 10	**Water Quality:** Water quality plays a critical role in the success of an aquaponics system, and the ability of fish, plants, and bacteria to thrive. Students will learn the key chemical parameters which impact system operation, the role of these parameters with a system, and proper methods for monitoring the parameters and permanent record-keeping. **Activities / Lab Exercises:** *(1) Water Quality Parameters poster project , (2) Water Quality Monitoring of Aquaponics Systems (ongoing for duration of academic year)*
1 week Chapter 12	**Plant Biology and Plant Crop Choices:** Students will receive an introduction to botany principles and plant biology, including seed germination, seedling transplanting, plant nurture and care, and harvesting. Principles of photosynthesis and cellular respiration will be investigated using plants in aquaponics systems. Favored crop selection for each

	system type will be discussed **Activities / Lab Exercises:** *(1) Seed Morphology , (2) Seed Germination and Root Structures , (3) Cellular Respiration and Transpiration , (4) From Seed to Harvest Project*
1 week Chapter 11	**<u>Fish Biology and Physiology, Fish Selection:</u>** Fish are the second living component of an aquaponics system. Students will learn the basic anatomy and physiology of fish, as well as freshwater fish types that are well-suited for aquaponics. Strengths and weaknesses of specific fish types, as well as water quality parameters affecting the selection of fish for a given system type will be discussed. Students will complete a dissection of a fresh tilapia, and be given an opportunity to fillet a tilapia. **Activities / Lab Exercises:** *(1) Fish Anatomy: Morphology and Function , (2) Tilapia Dissection , (3) Tilapia Filleting*
1 week Chapters 13 & 14	**<u>Nitrifying Bacteria and Microbiology:</u>** Bacteria are the third living component of an aquaponics system. Unseen, they are perhaps the most critical component, and are the engine for conversion of fish waste into plant nutrients. Students will learn about the nitrogen biogeochemical cycle, nitrifying bacteria and their role within an aquaponics system, and conditions within an aquaponics system which are necessary to maintain a thriving population of beneficial bacteria. **Activities / Lab Exercises:** *(1) Nitrogen Cycle , (2) Nitrifying Bacteria Identification: Gram Staining*
0.5 week Other Resources	**<u>Biosecurity and Intergrated Pest Management:</u>** Insects may play a beneficial and positive role, or a negative role in agriculture. Students will be introduced to insects commonly associated with controlled environment aquaponics systems, and will identify specific types associated with the aquaponics systems at CHCA. Biosecurity in controlled environment agriculture will be introduced. **Activities / Lab Exercises:** *(1) Sticky Pad Insect Identification , (2) Insects and Pests Poster Project*
0.5 week Other Resources	**<u>Recordkeeping, and System Operation & Maintenance:</u>** A key to long-term successful operation of any aquaponics system is having a robust data set of operational parameters associated with the system. Students will be responsible for year-long monitoring of operational paraemeters for a single system, with preparation of periodic reports of system health based on data trends. **Activities / Lab Exercises:** *(1) On-going System Monitoring and Reporting*
0.5 week Other Resources	**<u>Good/Best Agricultural Practices:</u>** Good Agricultural Practices are those which allow a commercial farmer to spend less time and money making mistakes, reduce your business risk of liability, and improve chances that customers will feel justified in paying a higher price for your produce. Students will investigate these practices as they pertain to small aquaponics systems in a controlled environment setting, and as an introduction to food production and food safety. **Activities / Lab Exercises:** *(1) Good Agricultural Practices – CHCA Aquaponics Laboratory*
1 week Other Resources	**<u>Food Production / Food Safety:</u>** Food production and food safety are interwoven with good/best agricultural practices. Students will investigate food production and safety practices in general, and then prepare guidelines for those practices which most applicable for fish and crops grown in the CHCA Aquaponics Laboratory. **Activities / Lab Exercises:** *(1) Food Production and Food Safety Plan project*
	End of 1st Quarter

	Unit 2. The Food System ***What is the Food System?*** The food system spans the activities, people and resources involved in getting food from field to plate. Along the way, it intersects with aspects of public health, equity and the environment. ***Why Teach the Food System?*** This study of the food system spans multiple subjects, including environmental science, biology and social studies. It can help prepare learners for careers in public health, policy, nutrition, agriculture and a variety of other fields
0.5 weeks	**Ingredients of the Food System:** After reflecting on the roles food plays in their lives, students will follow the stages along the supply chains of several foods from field to plate. They will explore the relationships between food, health, justice and the environment and depict them on posters and graphic organizers. **Activities / Lab Exercises:** *(1) Food System Supply Chains, (2) Food, Health, Justice, and the Environment, (3) Visualizing the Food System*
1 week	**History of Food:** The food system has experienced more changes in the past century than it had over the previous 10,000 years. Students will follow the transition from pre-agricultural societies to the prevailing industrial food system. They will create timelines and graphs depicting long-term trends. **Activities / Lab Exercises:** *(1) Agriculture and the Dawn of Civilization, (2) Cycles of Boom and Bust, (3) Industrialization of the Food System, (4) Concentration of Food Industries*
1 week	**Agriculture and Ecosystems:** Students will trace the ingredients of a meal back to their origins in the soil, reflecting on the connections between food, agriculture and ecosystems. They will assess some of the challenges facing agriculture and devise plans to address them. Organic and sustainable approaches to agriculture will also be discussed. **Activities / Lab Exercises:** *(1) Tracing Food to Soil, (2) Food, Agriculture, and Ecosystems, (3) Problems in Agriculture, (4) Assessing and Addressing Problems, (5) Alternative Farming Systems*
1 week	**Food Animal Production** Students will compare different approaches to raising food animals and assess the implications for health, rural communities, animal welfare and the environment. They will view the short film *Out to Pasture: The Future of Farming?* and respond to narratives from farmers, community organizers and researchers. Seafood harvest and production will also be discussed. **Activities / Lab Exercises:** *(1) Food Animal Production, (2) Seafood Harvest and Production, (3) "Out to Pasture": The Future of Farming*
1 week	**Food Processing** Students will explore the steps involved in manufacturing orange juice, chicken nuggets and other processed foods. Through examples, they will learn why and how foods are processed. In addition to the benefits of food processing, students will examine the dietary, health, justice, economic and environmental concerns associated with certain aspects of the industry. **Activities / Lab Exercises:** *(1) Degrees of Food Processing, (2) Why are Foods Processed?, (3) How are Foods Processed, (4) Concerns over Food Processing*
	End of 2nd Quarter / 1st First Semester
Dec 15 – 18	***First Semester Exams (Specific day to be announced at later date)***

	Beginning of Second Semester / Third Quarter ***Environmental Science II***
1 week	**<u>Food Distribution and Transport</u>** Students will explore the rationale for transporting food over long distances. They will map the distribution routes of feed, animals and food ingredients in the manufacture of beef and strawberry yogurt, then calculate the resulting energy and climate impacts. They will critically examine the strengths and limitations of local and regional food systems. **Activities / Lab Exercises:** *(1) Why Food is Transported, (2) Industry Consolidation, (3) Mapping Food Routes: Food Miles, Energy, and Climate Change, (4) Local and Regional Food Systems*
1 week	**<u>Food Safety</u>** Students will identify sources of bacterial and chemical contamination along the food supply chain. They will simulate an investigation of a foodborne illness outbreak; using survey data, graphs and other tools, they will determine the pathogen and contaminated food responsible. Ways of preventing contamination at the industry and household levels will also be discussed. **Activities / Lab Exercises:** *(1) Foodborne Pathogens from Field to Plate, (2) Outbreak Investigation, (3) Chemical Contaminants in Food, (4) Prevention and Education*
1 week	**<u>Diet and Influences on Food Choice</u>** Students will explore the relationship between diet and health, play a game about how American diets have changed over recent decades, and brainstorm reasons why people eat what they eat. They will learn about programs geared toward reducing the epidemic of diet-related diseases, then design their own intervention. **Activities / Lab Exercises:** *(1) Effects of Diet on Health, (2) Trends in American Diets, (3) Influences on Food Choice, (4) Improving American Diets*
1 week	**<u>Food Environments</u>** Students will examine how the environments in homes, schools, restaurants, stores and communities can affect what they eat. They will use tools such as maps and surveys to measure the cost, availability and accessibility of food in communities. Food maps of Baltimore City are included for in-class activities. Key concepts include food deserts and grocery gaps. **Activities / Lab Exercises:** *(1) Homes, Schools, Restaurants, Stores, (2) Communities, (3) Measuring & Improving Food Environments*
1 week	**<u>Food Marketing and Labeling</u>** Students will explore the effects of food marketing and labeling on food choice, including the influence of brand awareness on their own choices. In-class activities include brainstorms, discussions and a debate over the merits of pouring rights contracts. Students will apply key concepts through group projects. **Activities / Lab Exercises:** *(1) Food Marketing, (2) Food Labeling*
1 week	**<u>Hunger and Food Security</u>** After sharing their perspectives on how to define and measure hunger, students will explore the history, causes and consequences of hunger and food insecurity in the United States. Through discussions, activities and final projects, students will compare the strengths and limitations of emergency food programs, federal food and nutrition assistance, and the community food security movement. **Activities / Lab Exercises:** *(1) Hunger, (2) Food Security, (3) Interventions*
	End of Third Quarter

	Unit 3. Land Use This unit focuses on population and resources, emphasizing land use and ecology. Students will use the case of an overcrowded school district and the proposed construction of a new school to explore human resource use and to investigate the challenges of land use planning to minimize the impact on a threatened ecosystem.
3.5 weeks Chapters 1 & 2 (Volume 1)	**Introduction & Populations*:*** Chapter 1 addresses the issues and conflicts surrounding appropriate land use, including consideration of environmental impacts. Chapter 2 has an emphasis on growth of human populations, with particular focus on changes in the Earth's human population. Topics include the study of animal populations and how they shrink / grow based on the resources available to the; analysis of trends in population growth in different areas of the world utilizing data in the form of tables, graphs, and maps; prediction of future populations from trend analysis. **Activities / Lab Exercises**: *(1) New School Location – Overcrowded & Using Land Well, (2) Population Changes of Daphnia, (3) Census Analysis, (4) Population Growth, (5) Population Pyramids, (6) Factors Affecting Population Size, (7) Personal Decsion Making*
3.5 weeks Chapter 3 (Volume 1)	**Resources:** Focus on the resources that growing populations consume, with an emphasis on land, energy, and water. Topics include global availability of resources, including resource location, proximity of resources to populations, and transport of resources to meet population needs. Activities lead students to application of the Environmental Decision Making Process. **Activities / Lab Exercises**: *(1) Composting and Recycling of Matter in Controlled Ecosystems (on-going activity for balance of academic year), (2) The Area of a School, (3) Arable Land, (4) Energy Resources, (5) Energy from the Sun, (6) Temperatures on Earth, (7) Where is all the Water?, (8) Rainfall Distribution, (9) Climate Classes, (10) Biomes, (11) Heat Wave and Drought, (12) Protein Dilemma – Constraints, Considerations, and Consequences, and Stakeholders*
3 Weeks Chapter 4 (Volume 1)	**Ecosystems:** Addresses ecosystems, with a focus on understanding how ecosystems work, the interconnected relationships within them, and prediction of changes that will occur when the ecosystem is disturbed. Students will complete an environmental survey, and assess the environmental impact of a proposed school building on a current ecosystem. **Activities / Lab Exercises**: *(1) Vacant Land, (2) Gopher Tortoises and Land Use, (3) Ecosystem Land Notes, (4) Food Chains, (5) Energy in Ecosystems, (6) Biomagnification, (7) Food Chains to Food Webs, (8) Disturbances to Food Webs, (9) Everyone Has a Role, (10) Relationship Web, (11) Ecosystem or Species?*
	End of 4th Quarter / 2nd Semester
May 11 – 14	***Second Semester Exams (Specific day to be announced at later date)***

Appendix B

Example Classroom Activities

1. **Introduction to Aquaponics: Chapter 1: What Is Aquaponics?**
   Aquaponic Gardening, Sylvia Bernstein, © 2011

2. **Introduction to Aquaponics: Chapter 2: The Global Perspective**
   Aquaponic Gardening, Sylvia Bernstein, © 2011

3. **Introduction to Aquaponics: Podcast 1: What Is Aquaponics?**
   Bright Agrotech, LLC, Aquaponics Academy Podcast Series

4. **Water Quality Parameter Assignment: Poster Project**
   Environmental Science I Group Project Assignment

Environmental Science I
Mr. Delanoy / Dr. Savage 9/19/13

Introduction to Aquaponics
Chapter 1: What Is Aquaponics?
Aquaponic Gardening, Sylvia Bernstein, © 2011

In your *Aquaponic Gardening* text, please read the Preface (p. xix – xxvii), the Section 1 Introduction (gray pages), and Chapter 1, "*What is Aquaponics*".

Preface

1. The author says that this text is entirely focused on media-based aquaponics systems, rather than on other types of aquaponics systems in use. What are the two primary reasons she cites for focusing on media-based systems?

   The two primary reasons are solids filtration and planting flexibility. (2 points)

2. On page 1 of the text, there is an extended definition of "aquaponics". After reading the definition, list two ways in which aquaponics might be a good alternative to our industrial food production system, and explain why.

   Personal answer – do the reasons given make sense? (2 points each for 2 reasons; 4 points total)

3. Aquaponics is the combination of what two sustainable agriculture or cultivation techniques?

   Aquaculture (fish farming) and hydroponics (growing plants without soil) (2 points)

4. List the five ways that aquaponics is an improvement over hydroponics.

   - **Expensive chemical nutrients are replaced with inexpensive fish food**
   - **You never have to dump your nutrient solution**
   - **Maintaining an aquaponics system is significantly easier**
   - **Aquaponics is more productive**
   - **Aquaponics is completely organic** **(5 points)**

5. When and where is aquaculture believed to have begun? When and where did the "modern" era of aquaculture begin?

   Believed to have begun around the 6th century B.C. in China; the modern era is general acknowledged to have begun in the 1730's in Germany. (2 points)

6. What is the main disadvantage of recirculating aquaculture systems?

   The amount of waste that the fish produce, and the entire waste disposal process. (2 points)

7. On page 8, there is a quote from a February 2010 *New York Times* article that describes a particular aquaponics setup in Connecticut as "… either a glimpse at the future of food growing, or a very strange hobby – possibly both …". Which one of these options resonates most with you? Why?

   Personal opinion question … is their answer reasonable? (4 points)

Environmental Science I
Mr. Delanoy / Dr. Savage 8/26/14

Introduction to Aquaponics
Chapters 2: The Global Perspective, p. 9-25
Aquaponic Gardening, Sylvia Bernstein, © 2011

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1. What are the two main factors, or "drivers", for the expected increase in global demand for food over the next forty years? **(2 points)**

   - **Growing global population**
   - **Increasing standards of living for developing nations**

2. Demographers (people who study population demographics), predict that the global population will grow from 7 billion people to nine (and some say 10!) billion people by 2050. In what four geographic regions is the overwhelming majority of the growth expected to occur? **(4 points)**

   - **Asia**
   - **Africa**
   - **Latin America**
   - **Caribbean**

3. What is meant by the statement "… humanity's impact on the planet's living resources, its Ecological Foorprint, now exceeds the planet's regenerative capacity by 30 per cent …"? What is the long-term implication of this?

   We are now consuming planetary resources faster that they can/are being regenerated, including the planet's ability to process waste. (2 points)

   Likely results of this will include deforestation, water shortages, declining biodiversity, and climate change. All of these factors put the well-being and development of nations at risk. (2 points)

4. What two nations are expected to experience the greatest increase in standard of living over the next 40 years? What is the big picture implication if this happens?

   China and India. (2 points)

   This may lead to the rise of higher-consuming middle classes, and increase the demand for a Western-type lifestyle, especially regarding the consumption of food products (especially meat). (2 points)

5. What is one large potential problem that we face as we consider the role of water in agriculture? **(1 point)**

- **Only 2.5% of Earth's water is fresh water; less than 1% is available for human use**
- **Agriculture presently consumes 75% of fresh water (in USA ~ 80%, in Africa ~90%)**
- **Aquifer depletion**
- **Ground and surface water pollution from agricultural chemical (fertilizers, pesticides, etc.)**

6. What is the role of conventional industrial agriculture with respect to climate warming? **(2 points + EP)**

It may be the single biggest contributor to global climate change by production of greenhouse gases:

- **CO_2 from the heavy use of equipment to grow, harvest, transport, and process food items;**
- **N_2O (nitrous oxide) release from chemical-based fertilizers and fossil fuel combustion;**
- **CH_4 (methane) from the production of livestock**

7. Summarize the benefits of aquaponics over traditional and industrial farming methods with respect to the following areas: (1) petroleum / fossil fuel usage, (2) water use, and (3) climate change. **(6 points)**

Petroleum / fossil fuels: While some energy is needed in aquaponics to heat water and power pumps that move the water and supply dissolved oxygen to the fish, the need for petroleum and fossil fuels for production is significantly less and power needs may be supplemented by renewable energy sources, such as solar or geothermal energy. Sales and use of plants and fish locally greatly reduces product transportation and fuel consumption.

Water: Unlike traditional/industrial agricultural practices which waste/lose much water, aquaponics is a closed-loop recirculating system which uses and loses significantly less water.

Climate change: As noted above, traditional/industrial agriculture may be the single biggest contributor to GCC. Aquaponics eliminates or greatly reduces the production of the critical GHGs responsible for much/most of GCC, and is therefore a very minor contributor. Use of renewable energy sources to meet aquaponics energy needs may result in near-zero contribution to GCC.

8. What is the primary benefit of aquaponics over aquaculture? **(2 points)**

The primary benefit is that bacteria in the recirculating aquaponics system break down the potentially-toxic fish wastes from the aquaculture portion of the system, resulting in an "organic" nutrient for plants in the hydroponic portion of the system. This is biofiltration, and helps to clean the water which returns to the fish.

Bonus: What percentage of Earth's water is actually available for human use as fresh water? ____**$\leq$ 1%**__________

Environmental Science I
Mr. Delanoy / Dr. Savage

Name: ____**KEY**______________________

Introduction to Aquaponics
Podcast 1: What Is Aquaponics?
Aquaponics Academy

Directions:

1. Listen to the podcast "Aquaponics Academy Episode 1" on Netclassroom or at Bright Agrotech's Youtube channel https://www.youtube.com/watch?v=dpENi0T3Zeo

2. Answer the guided questions as you listen to the podcast.

Questions:

1. What are the three main components of an aquaponics system? (*3 pts*)

   Fish, plants, microbes (bacteria)

2. According to Dr. Story, what analogy does he use to describe the three components and how they interact if they do so? *(2 pts)*

   Two countries (plants and fish) connected by a bridge (microbes / bacteria)

3. What is meant by the term "bioavailable" in terms of fish waste and plant nutrients? Explain. *(2 pts)*

   The conversion of fish waste into nutrients available to plants through the action of microbes.

4. How would we discern which of the three components of the aquaponics system is most critical to the entire operation? Explain and identify which component is the most critical to an aquaponics system. *(2 pts)*

   Microbes – they do all of the work of bioconversion of waste to nutrients; the fish and plants are 'along for the ride". The microbes are critical because if we remove them from the system, the system will crash.

5. How are aquaponics and hydroponics related? Explain. *(2 pts)*

   Aquaponics is a specialized form of hydroponics that utilizes fish waste as a source for nutrients for plants, rather than chemical solutions.

6. Given the following terms, draw/sketch a flowchart or diagram to show the relationship among them: (microbes, waste, plants, clean water, fish, and nutrients) *(5 pts)*

   Fish → Fish waste → Action of microbes → Nutrients for plants → Plants → Clean water → Fish (cycles)

Environmental Science I
Mr. Delanoy / Dr. Savage 9/23/14

Water Quality Assignment: Poster Project

Throughout the remainder of the school year, this class will be monitoring and tracking the water quality of one or more of the aquaponics systems in this classroom. We began this process last week with the water quality monitoring exercise during our block period last week. Our successful operation of multiple aquaponics systems will begin with a thorough understanding of the quality of the water in which the fish and bacteria live, and in which the plants are rooted. Although the ultimate goal is for each of you to have an understanding of each water quality parameter, and its role in the health and productivity of the aquaponic system, you will start by researching the parameter which you and your partner were assigned last week on block day.

The objectives of this activity include:

- Develop an understanding of how the chemistry of an aquatic system affects the biotic (living) organisms in that system.
- Be able to develop the skills of an analytical chemist performing the water quality tests using different field and laboratory methods.
- Use the information gathered to determine how the "health" of the system can be used to understand aquatic systems outside of the classroom such as local bodies of water; ponds, creeks, rivers, lakes, and groundwater.
- Make a connection to the chemical topics studied in class to more global topics of available of drinking water and water pollution.

To complete this exercise, each group will develop an "informational" poster using a single PowerPoint slide covering the parameter they will be monitoring for the remainder of the semester (and perhaps school year). These posters will be laminated and displayed in my classroom or lab, so it is important to me that you and your partner(s) do your best on this project. All posters are to be formatted as a 11" x 17" slide; it may be oriented either portrait or landscape..

The following information is to be included on the poster:

- Name of parameter (e.g., Alkalinity)
- Describe "what is the parameter" (e.g., "What is Alkalinity?")
- Describe why it is important to measure this parameter (e.g., "Why measure Alkalinity?")
- Describe the factors in the environment that affect the parameter (e.g., "What factors affect alkalinity?")
- Describe the "normal" range of measurements for the parameter for (1) a natural aquatic system (lake, river, or pond) located in southwestern Ohio, and (2) an aquaponic system (e.g., "What is the normal range of alkalinity values?") These measurements should be related to raising freshwater fish found in Ohio's natural waters, and freshwater fish and plants being raised in an aquaponic system.
- Briefly describe how the parameter will be measured (e.g., using a specific probe and the Pasco GLX Explorers, using a test kit comparing colorimetric tests, or using a test kit and a colorimeter), and outline the general steps of the test procedure.
- Include the names of the group members responsible for the work.
- References for all sources should be included either on the front of the poster, or as a second slide that would be laminated as the back of the poster.

Include pictures, sketches, graphs, etc., that would make your information easier to read and more understandable to someone who understand little or nothing a freshwater aquatic systems, or aquaponics.

In order for you to fit all information on the slide, it may be necessary for you to edit your sections to include the most important points.

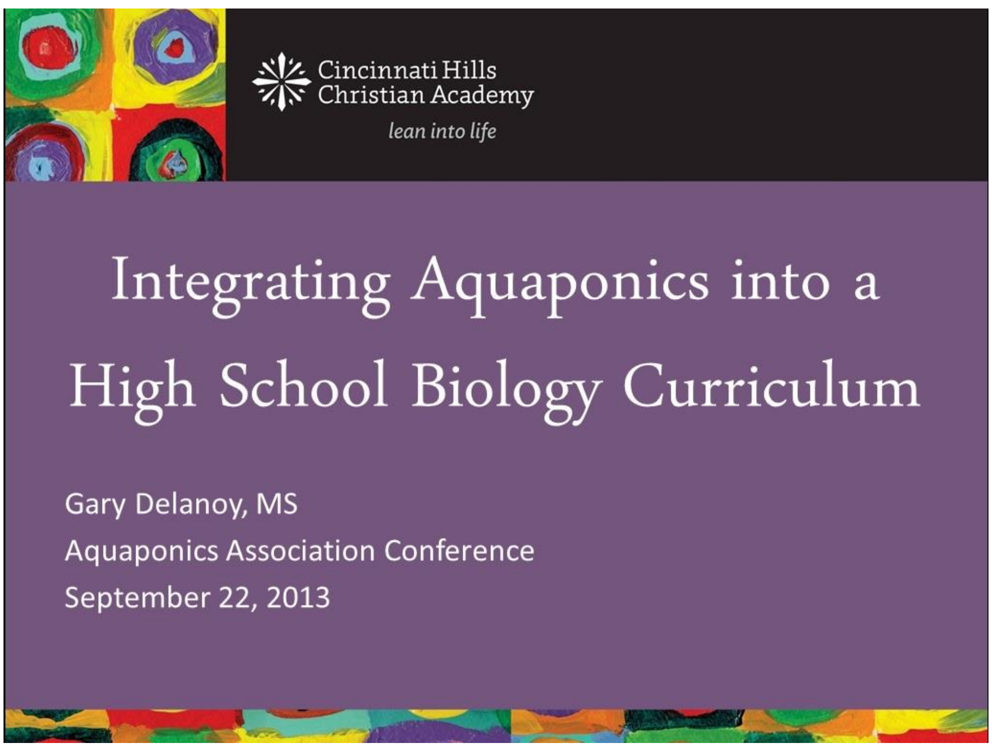
Water Quality Assignment: RUBRIC **Names: ______________________________________**

Category	5	4	3	0
Format	• Poster format • Title clearly given • All items of importance clearly labeled	• One item missing or incomplete	• Two items missing or incomplete	missing
Graphics: Clarity relevance	• graphics all in focus and easily viewed and/or identified	• graphics may be blurry or overlap content	graphics may be blurry and overlap content	Missing
Attractiveness	• all graphics related to topic • graphics make poster easier to understand • Poster exceptionally attractive in terms of design, layout, and neatness.	• At least one item missing or incomplete	At least two or more items missing or incomplete	Missing
Mechanics & Grammar	• capitalization and punctuation correct throughout poster • no grammatical mistakes	• At least one item missing or incomplete	At least two or more items missing or incomplete	Missing
Content: Describe parameter X2	• informative description of parameter • relates to other parameters • specific examples & details provided	• parameter somewhat described	Description given but does not relate to freshwater fish/plants	Missing
Content: Why measure? X2	• Description why parameter important to water quality	• Description somewhat complete	Description given but does not relate to freshwater fish/plants	Missing
Content: factors affect parameter X2	• Description how other parameters/factors (i.e. temp. or pH) affect parameter	• Description somewhat complete	Description given but does not relate to freshwater fish/plants	Missing
Content: describe ideal measurements X2	• Clear comparison of ideal values (i.e. concentrations) with different types of bodies of water.	• More than two different types of water compared	Ideal measurements on compared to one other type of water	Missing
Content: Describe how parameter measured X2	• Brief description how parameter measured. • May include colorimetric determination, color comparison, or use of a sensor	• Description somewhat complete	Description given but does not relate to freshwater fish/plants	missing
Citations: Content & Images	• Content clearly listed • Images are individually cited	• One item missing or incomplete	Two items missing or incomplete	Section missing
Total (75 pts.)				

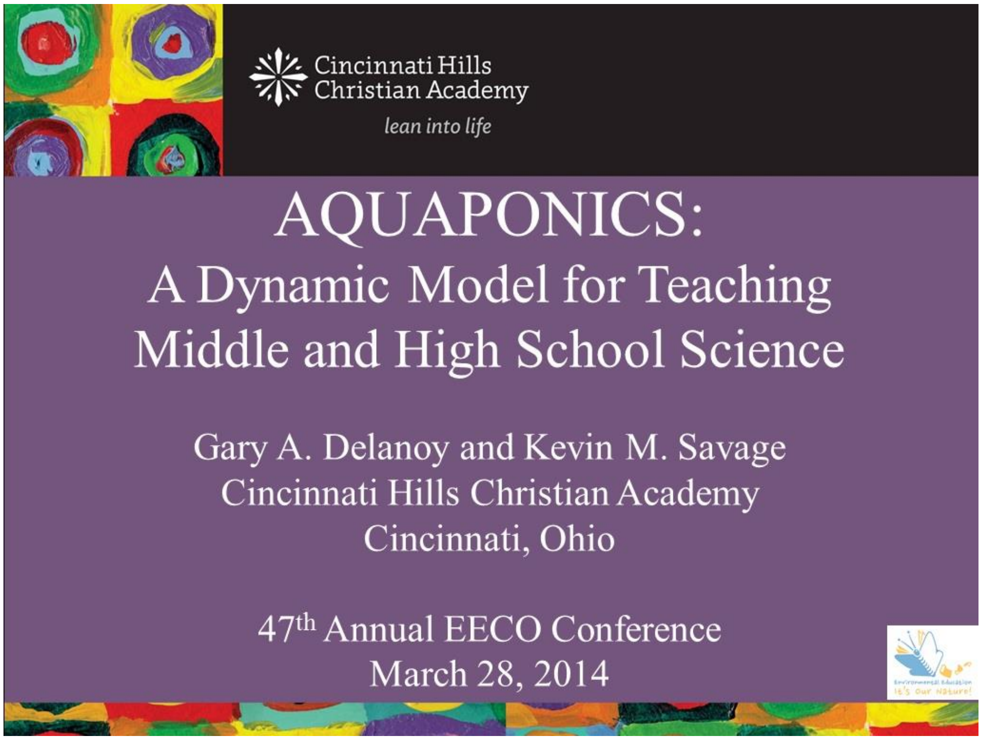
Appendix C

Presentation Title Slides

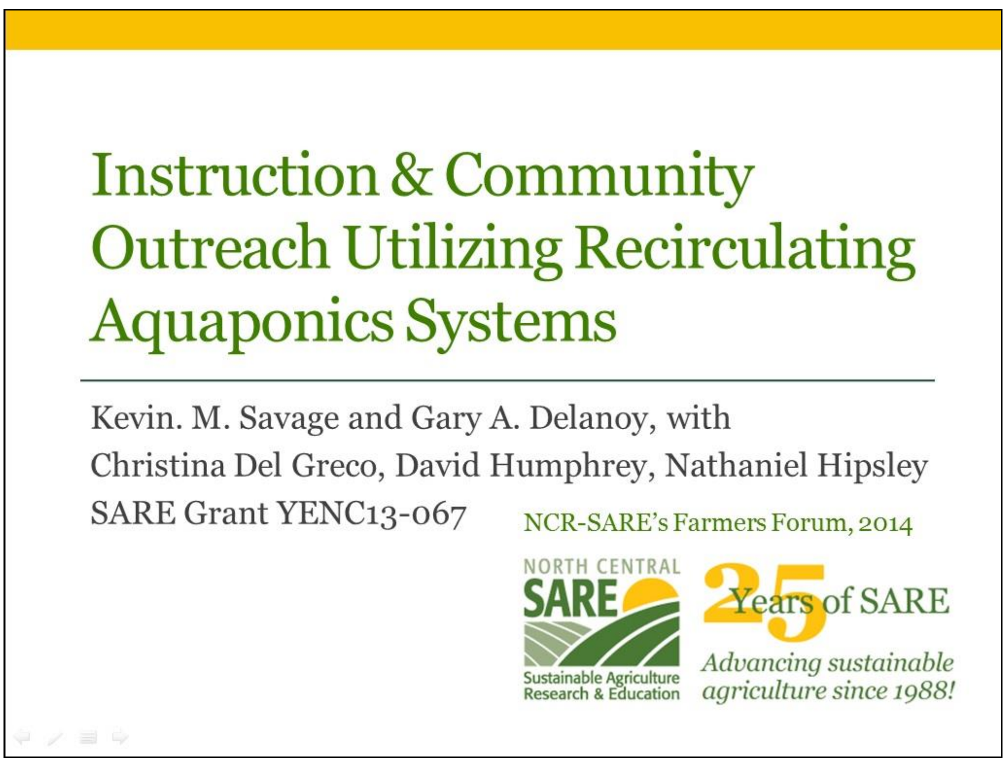
2013 Aquaponics Association International Conference, Denver, CO



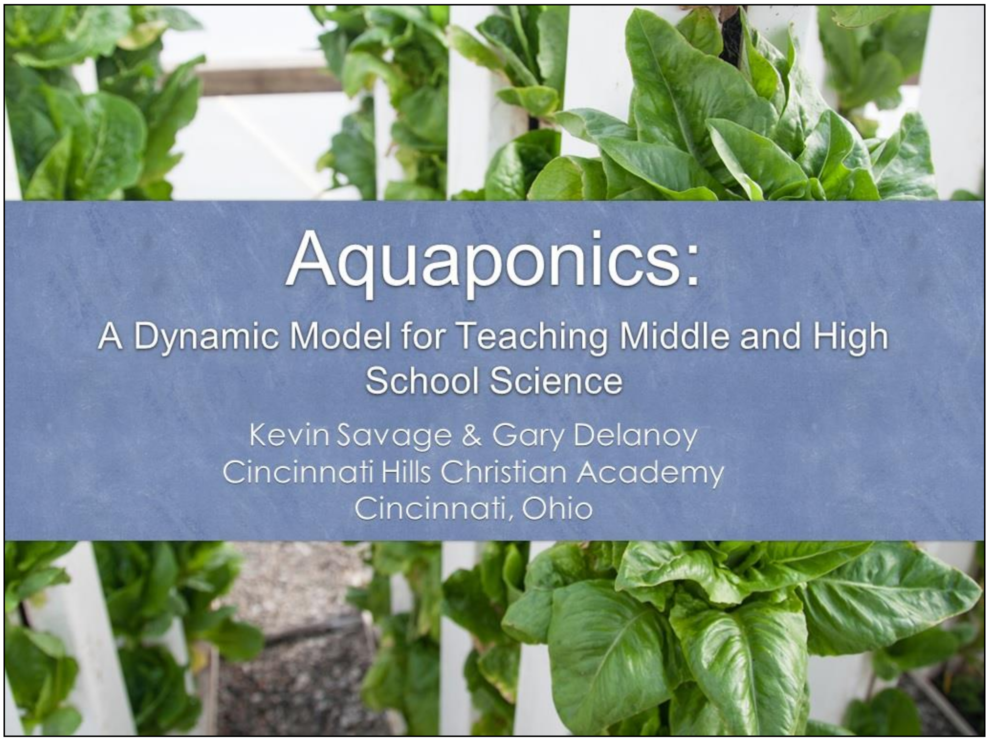
47th Annual Environmental Education Council of Ohio Conference, Deer Creek State Park, Ohio



NCR-SARE Farmer's Forum, 2014 Ohio Ecological Food and Farm Association Annual Conference, Pickerington, Ohio



Bright Agrotech Educator's Webinar, September 2014
(www.brightagrotech.com)



2015 5th Annual Tri-State Green Industry Conference, Cincinnati, OH

2015 Environmental Education Council of Ohio – Winter Snow STEM Conference, Camp Nuhop, Perrysville, Ohio